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Research Paper

Influence of cereal–legume combination and sources of nutrients on productivity and profitability under organic production system

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ABSTRACT

A field experiment was conducted during rainy (*kharif*) and winter (*rabi*) seasons of 2012–13 and 2013–14 on sandy loam soil at experimental farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Research Sub-Station, Akrot, District Una, Himachal Pradesh to study the production potential of cereal–legume based cropping system and nutrient sources on productivity under organic conditions. The cropping sequence maize (*Zea mays* L.) + blackgram [*Vigna mungo* (L.) Hepper]–chickpea (*Cicer arietinum* L.) resulted in higher total maize-equivalent yield and benefit: cost ratio. Maize-equivalent yield of this system was statistically at par with maize + blackgram – wheat (*Triticum aestivum* (L.) emend. Fiori & Paol.] + chickpea cropping sequence. Vermicompost (VC) @ 10 t/ha recorded higher maize-equivalent yield of cropping system over VC @ 5 t/ha + liquid manure (LM) vermiwash and was statistically at par with VC @ 5 t/ha + LM + biofertilizers and VC @ 5 t/ha + biofertilizers. Application of VC @ 5 t/ha + LM + biofertilizers recorded the highest benefit: cost ratio (1.44). Higher values of available nitrogen (289.8 kg/ha), phosphorus (23.1 kg/ha) and potassium (176.2 kg/ha) in soil were recorded in VC @ 5 t/ha + LM + biofertilizers than the other nutrient sources.

Key words: Blackgram, Chickpea, Cropping system, Maize, Nutrient sources, Organic, Wheat

Out of 30 major cropping systems identified in India, maize-based cropping system is predominant in rainfed hilly areas, of which maize–wheat is the dominant cropping system. The contribution of this cropping system to total food grain production of the country is considerably large (GoI, 2016). Cropping systems involving legumes and cereals together in the same field for multiple food production has been and is still a popular practice among small scale farmers (Fujita *et al*., 1990). Legumes, with their adaptability to different cropping pattern and their ability to fix nitrogen, may offer opportunities to sustain increased productivity (Jeyabal and Kuppuswamy, 2001). Therefore, productivity is potentially enhanced by the inclusion of a legume in a cropping system (Maingi *et al*., 2001). In addition, legume intercrops are included in cropping systems because they reduce soil erosion and suppress weeds. The success of any cropping system depends upon the appropriate management of resources including balanced use of manures.

Use of organic manures may prove a viable option for sustaining the productivity of legumes and adds life to the soil. The application of appropriate amounts of organic manure is the key for success of organic farming. The role of biofertilizers for enhancing the productivity of soil by fixing atmospheric nitrogen, or by solubilising soil phosphorus, or by stimulating plant growth through synthesis of growth promoting substances has special importance in organic farming. Under organic conditions, application of liquid organic manures is essential to maintain the activity of micro-organisms and other life forms in the soil. A healthy soil can be maintained by continuous incorporation of crop residues, animal dung, urine based manures (FYM, vermicompost etc.), biofertilizers, special liquid manures (viz. vermiwash, compost biosol, matka khad *etc*.) as well as inclusion of legume component in cropping system as intercrop or as green manure. Therefore, an experiment was undertaken to find out the effect of cereal + legume cropping systems and nutrient sources on productivity and economics under organic conditions.

MATERIALS AND METHODS

A field experiment was conducted during rainy (*kharif*) and winter (*rabi*) seasons of 2012–13 and 2013–14 at ex-

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perimental farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Research Sub-Station, Akrot, District Una, Himachal Pradesh ($30^o6'$ to $32^o5'$ N, and $75^o5'$ to $77^o5'$ E, about 425 m above mean sea-level). The soil of the experimental field was sandy loam in texture, having *p*H 6.5, available N 280 kg/ha, available P_2O_5 18.5 kg/ha and available K_2O 170 kg/ha. The experiment was laid out in factorial randomized block design with 3 replications. There were 16 treatments comprising of combinations of 4 nutrient sources, viz. vermicompost (VC) @ 10 t/ha, VC @ 5 t/ha + liquid manure (LM) vermiwash, VC @ 5 t/ha + biofertilizers and VC @ 5 t/ha + LM + biofertilizers with 4 cropping sequences, viz. maize + blackgram–wheat + chickpea, maize + blackgram–chickpea, blackgram–wheat + chickpea and blackgram–chickpea. Maize 'Early composite', wheat 'HPW 155', black gram 'UG 218' and chickpea 'Himachal Chana 1' were sown on 10 and 12 July during first and second year of experimentation with recommended package of practices. For comparison between crop sequences, the yield of all crops was converted into maize-equivalent yield. After harvest, grain yield and straw yield/ha were recorded. Soil samples were collected during both the years after harvesting. The available N content of soil was analysed by Micro-kjeldahl's method, P by Olsen's method and K by flame photometer method. Benefit: cost ratio was worked out by dividing gross returns (₹/ha) with cost of cultivation (₹/ha). Quality parameters of wheat, blackgram and chickpea grown organically and inorganically were recorded by following standard procedure. There was no severe attack of any insect-pests and disease; however general schedule of bioformulations was used to manage insect-pests and diseases (Table 1). The different bioformulations include *Lantana* extract which is a solution containing 4 kg fresh *Lantana* leaves mixed in 12 litres of cow urine in equal amount of water kept for 15 days fermentation. *Tamra lassi* is a solution containing 5 litres fermented butter milk in copper vessel for 15–20 days with proper stirring. *Panchgavya* is prepared by mixing 2 kg fresh cow dung, 3 litres cow urine, 2 litres milk, 2 litres curd and 1 kg desi ghee and fermented for 10–15 days. These bioformulations were sprayed at 15 days interval starting after one month crop. Since data followed the homogeneity test, pooling was done over the seasons and mean data were presented. For calculating the maize-equivalent yield the price of different crops taken were: maize @ ₹10/kg, wheat @ ₹13/kg, blackgram @ ₹60/kg and chickpea @ ₹40/kg.

Table 1. Bioformulations for insect-pests and disease management in rainy (*kharif*) and winter (*rabi*) season

Bioformulations	Quantity	No. of spray
Kharif		
Lantana extract	10%	3
Neem oil	3 ml/lt	2
Tamra lassi	10%	2
Rabi		
Panchgavya	10%	2
Neem oil	3 ml/lt	1
Nucleo polyhedrosis virus (NPV) hali	3 ml/lt	2
Bacillus thuringiensis (Bt)	2.5 g/lt	1
Tamra lassi	10%	2

RESULTS AND DISCUSSION

Productivity

Maize-equivalent yield reflects the total productivity of the cropping systems (Table 2). In maize + blackgram–wheat + chickpea and maize + blackgram–chickpea sequence higher maize-equivalent yield was recorded with application of vermicompost (VC) @ 10 t/ha which was statistically at par with VC @ 5 t/ha + LM + biofertilizers in maize + blackgram–chickpea. It might be due to the fact that vermicompost improved the physical and biological properties of soil including supply of almost all the essential plant nutrients and development of the plant. Application of VC @ 5 t/ha + LM + biofertilizers in maize + black gram – chickpea sequence obtained higher maize-equivalent yield and was statistically at par with VC @ 5 t/ha + biofertilizers and VC @ 10 t/ha. In blackgram–chickpea sequence, application of VC @ 5 t/ha + LM + biofertilizers resulted in significantly higher maize-equivalent yield over other nutrient sources and was statistically at par with VC @ 5 t/ha + LM vermiwash. The crop sequence involving legumes played an important role in restoring the soil fertility in terms of N and other biological parameters due to atmospheric N-fixation through symbiotic process, which in turn improved the yield of succeeding crop compared with that of the cereal crop sequence. Similar findings were also observed by Ramesh and Reddy (2004).

Among the cropping systems, maize-equivalent yield was recorded significantly higher in maize + blackgram–chickpea as compared to the other cropping sequences. However, it was statistically at par with maize + blackgram–wheat + chickpea cropping system. Singh and Sharma (2002) also reported beneficial effect of legumes on the succeeding crops. The improvement in productivity in these crops can be ascribed to fixation of atmospheric nitrogen by legume crops, which might have improved the fertility status of soil. Inclusion of pulses also helped in achieving higher maize-equivalent yield than with sequences having cereal crops (Table 3).

Table 2. Effect of different cropping systems and nutrient sources on yield and maize-equivalent yield (pooled data of 2 years)

Cropping sequences and nutrient sources	Yield (t/ha)				Maize-equivalent yield of cropping system (t/ha)
	Kharif	*Kharif* intercrop	*Rabi*	*Rabi* intercrop	
Maize + blackgram–wheat + chickpea					
F_1, VC @ 10 t/ha	2.91	0.19	1.64	0.87	9.12
F_2, VC @ 5 t/ha + liquid manure (LM) vermiwash	2.59	0.15	1.27	0.61	7.06
F_3, VC @ 5 t/ha + biofertilizers	3.06	0.13	1.11	0.75	7.91
F_4, VC @ 5 t/ha + LM + biofertilizers	2.83	0.14	1.20	0.77	7.92
Maize + blackgram – chickpea					
F_1, VC @ 10 t/ha	3.10	0.15	1.37		9.14
F_2, VC @ 5 t/ha + liquid manure (LM) vermiwash	2.71	0.13	1.05		7.47
F_3, VC @ 5 t/ha + biofertilizers	2.74	0.13	1.05		7.42
F_4, VC @ 5 t/ha + LM + biofertilizers	3.10	0.14	1.24		8.60
Blackgram – wheat + chickpea					
F_1, VC @ 10 t/ha	0.52		1.80	0.57	6.53
F_2, VC @ 5 t/ha + liquid manure (LM) vermiwash	0.51		1.61	0.59	6.35
F_3, VC @ 5 t/ha + Biofertilizers	0.45		1.88	0.67	6.74
F_4, VC @ 5 t/ha + LM + Biofertilizers	0.41		2.07	0.72	6.99
Blackgram–chickpea					
F1, VC @ 10 t/ha	0.45		0.95		5.59
F2, VC @ 5 t/ha + liquid manure (LM) vermiwash	0.48		0.98		5.84
F3, VC @ 5 t/ha + biofertilizers	0.48		0.98		5.82
F4, VC @ 5 t/ha + LM + biofertilizers	0.51		1.09		6.40
SEm±					0.19
CD (P=0.05)					0.56

Economics

The higher net returns and benefit: cost ratio were obtained under maize + blackgram–chickpea followed by maize + blackgram–wheat + chickpea among the different cropping system. Lowest benefit: cost ratio was recorded under blackgram–chickpea cropping sequence. Among the nutrient sources, it is inferred that the highest net returns and benefit: cost ratio were obtained with application of VC @ 5 t/ha + LM + biofertilizers as compared to other nutrient sources (Table 3).

Soil-nutrient status after harvesting

Soil *p*H remained unaffected with cropping sequences and nutrient sources (Table 3). There was significant im-

Table 3. Effect of different cropping systems and nutrient sources on total maize-equivalent yield and economics (pooled data of 2 years)

Treatment	Maize-equivalent yield of cropping system (t/ha)	Net returns (×10³ ₹/ha)	Benefit: cost ratio	*p*H	Available nutrients (kg/ha)		
					N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
Cropping sequences							
C_1, Maize + blackgram – wheat + chickpea	8.00	81.3	1.46	6.7	282.3	18.8	169.4
C_2, Maize + blackgram – chickpea	8.16	83.5	1.77	6.7	283.5	21.6	175.2
C_3, Blackgram – wheat + chickpea	6.65	59.2	1.12	6.6	287.0	22.1	177.4
C_4, Blackgram – chickpea	5.91	44.1	0.99	6.5	290.3	19.7	173.0
SEm±	0.22			0.1	2.9	0.6	1.9
CD (P=0.05)	0.66			NS	8.8	1.8	5.9
Nutrient sources							
F1, VC @ 10 t/ha	7.60	71.4	1.35	6.5	285.2	19.9	172.9
F2, VC @ 5 t/ha + liquid manure (LM) vermiwash	6.68	59.2	1.19	6.6	281.0	18.6	171.7
F3, VC @ 5 t/ha + biofertilizers	6.97	65.7	1.36	6.6	287.1	21.5	174.2
F4, VC @ 5 t/ha + LM + biofertilizers	7.48	71.8	1.44	6.8	289.8	22.2	176.2
SEm±	0.22			0.1	2.9	0.6	1.9
CD (P=0.05)	0.66			NS	8.8	1.8	5.9

Table 4. Quality parameters of organically and inorganically grown wheat, blackgram and chickpea

Quality parameters	Organic	Inorganic	Per cent difference
		Wheat	
Carbohydrates (%)	72.05	72.64	–0.81
Crude protein (%)	11.14	10.25	+8.68
Crude fat (%)	1.78	1.64	+8.54
Crude fiber (%)	1.05	1.25	–16.00
Vitamin C (mg/kg)	4.26	4.52	–5.75
Vitamin A	BDL (MDL 200 µg/100g)	BDL (MDL 200 µg/100g)	–
Vitamin B1	0.44 mg/100g	0.42 mg/100	–4.76
		Blackgram	
Carbohydrates (%)	64.02	67.18	–4.70
Crude protein (%)	18.88	15.65	+20.64
Crude fat (%)	1.90	2.77	–31.41
Crude fiber (%)	7.33	7.57	–3.17
Vitamin C (mg/kg)	4.13	3.24	+27.47
Vitamin A	BDL (MDL 200 µg/100g)	BDL (MDL 200 µg/100g)	-
Vitamin B1	0.09 mg/100g	0.06 mg/100	+50.00
		Chickpea	
Carbohydrates (%)	62.90	66.74	–5.75
Crude protein (%)	22.88	18.85	+21.38
Crude fat (%)	0.68	0.58	+17.24
Crude fiber (%)	3.45	2.58	+33.72
Vitamin C (mg/kg)	10.18	10.80	–5.74
Vitamin A	BDL (MDL 200 µg/100g)	BDL (MDL 200 µg/100g)	–
Vitamin B1	0.12 mg/100g	0.11 mg/100	+9.09

provement in N status in all cropping sequences and maximum value of N was recorded in blackgram–chickpea and was statistically at par with blackgram–wheat + chickpea, maize + blackgram–chickpea and maize + blackgram–wheat + chickpea. Nyoki and Ndakidemi (2016) reported that it might be due to ability of leguminous crop to form symbiotic relationship with rhizobium and fix atmospheric nitrogen. However, available P in soil was observed the highest in blackgram–wheat + chickpea which was statistically at par with maize + blackgram–chickpea. Available K in soil was obtained the highest in blackgram–wheat + chickpea and was statistically at par with maize + black gram–chickpea and black gram – chickpea. Among the nutrient sources, VC @ 5 t/ha + LM + biofertilizers significantly influenced the available NPK in soil over other treatments; however, it was at par with VC @ 5 t/ha + biofertilizers, VC @ 10 t/ha and VC @ 5 t/ha + LM in case of N and K (Table 3). Whereas, in case of P, it was at par with VC @ 5 t/ha + biofertilizers. The increase in available N in soil might be due to the fact that application of vermicompost have reduced the nitrogen losses, improved fertilizer-use efficiency and thus increased the availability of nitrogen. The addition of organic matter in soil might have decreased the phosphate fixation due to the formation of phosphohumic complexes, that easily assimilated by plants, which ultimately increased the available P in soil. The increase in available K in soil might be due to the fact that addition of organic matter in soil have increased the cation exchange capacity, reduced the leaching losses, which ultimately increased the availability of K in soil. Similar results were also reported by Seth *et al*., (2016).

Quality parameters

It is evident from Table 4 that crude protein, crude fat and vitamin B1 contents of organically grown wheat were slightly more in comparison to inorganically grown counterparts with the per cent difference of +8.68, +8.54 and +4.76 respectively. Irrespective of the growing conditions, i.e. organic and inorganic, vitamin A content was below detectable limits (BDL) [minimum detectable limits (MDL) was 200 µg/100 g]. In case of blackgram (Table 4), crude protein, vitamin C and vitamin B1 contents of organically grown blackgram samples were towards higher side in comparison to conventionally grown counterparts with per cent difference of +20.64, +27.47 and +50.00 respectively. On the contrary the values for all the other parameters under study had more values for inorganically grown blackgram samples with per cent difference of –4.70, –31.41 and 3.17 for carbohydrates, crude fat and crude fiber, respectively. Vitamin A content of organically as well as inorganically grown black gram was below detectable limits. In case of chickpea (Table 4), values for crude protein, crude fat, crude fiber and vitamin B1 contents in organically grown chickpea samples were comparatively towards higher side with per cent difference of +21.38, 17.24, +33.72 and +9.09 respectively. Vitamin A content of organically as well as inorganically grown blackgram was below detectable limits.

Based on the results of present study, it was concluded that application of VC @ 10 t/ha in maize + blackgram–chickpea recorded higher system productivity and maintained NPK level of soil in cereal–legume based cropping system in low hill region of Himachal Pradesh.

REFERENCES

Fujita, K., Ogata, M.K., Masuda, T., Ofosu-Budu, K.G. and Kuwa, K. 1990. Nitrogen transfer and dry matter production in soybean and sorghum mixed cropping system at different population densities. *Soil Science and Plant Nutrition* **36**(2): 233–241.

GoI. 2016. *Agricultural Statistics at a Glance.* Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi (*www.dacnet.nic.in*).

Jeyabal, A. and Kuppuswamy, G. 2001. Recycling of organic wastes for the production of vermicompost and its response in rice–legume cropping system and soil fertility. *European Journal of Agronomy* **15**(3): 153–170.

Maingi, M.J., Shisanya, A.C., Gitonga, M.N. and Hornetz, B. 2001. Nitrogen fixation by common bean (*Phaseolus vulgaris* L.) in pure and mixed stands in semi-arid south-east Kenya. *European Journal of Agronomy* **14**(1): 1–12.

Nyoki, D. and Ndakidemi, P.A. 2016. Intercropping system, *rhizobia* inoculation, phosphorus and potassium fertilization: A strategy of soil replenishment for improved crop yield. *International Journal of Current Microbiology and Applied Sciences* **5**(10): 504–522.

Ramesh, P. and Reddy, K.S. 2004. Productivity and nutrient balance of soybean-based cropping system as influenced by nitrogen levels in deep vertisols of central India. *Indian Journal of Agronomy* **49**(3): 140–142.

Seth, M., Rameshwar, Saini, J.P., Sharma, R.P. and Sharma, K.D. 2016. Productivity and economics of wheat (*Triticum aestivum*) + chickpea (*Cicer arietinum*) intercropping under irrigation and nutrient management. *Indian Journal of Agronomy* **61**(3): 286–291.

Singh, V.K. and Sharma, B.B. 2002. Economic evaluation of rice (*Oryza sativa*)-based cropping sequences in foothills of Himalayas. *Indian Journal of Agronomy* **47**(1): 12–19.